- **ISO Tank Containers (employed with FDHS)**

ISO Tank Containers (see figures 1 and 2) are cylindrical carbon steel pressure vessels, surrounded by a 20’ x 8’ x 8.5’ framework (the overall international standard dimensions of a T11 container) for the transportation, storage and horizontal discharge of hazardous and non-hazardous liquid chemicals in bulk. Each ISO Container has up to a 6,500 gallon capacity, and weighs approximately 8,000 pounds empty, and will weigh approximately 75,000 pounds full, when filled with neutralent. Specific to the FDHS, they will be Polytetrafluoroethylene (PTFE) lined to accommodate extreme pH (hydrofluoric and hydrochloric acids) and temperatures up to 200°F, as well as to address compatibility with effluent.

During processing, the effluent lines from the process equipment will run to a common manifold located outside the Environmental Enclosure that will be used to connect waste into one of five Neutralent waste ISO tank containers. These will be connected via flexible hoses and filled manually. After contents achieve desired minimum temperature (< 150 F), they will be connected to discharge contents to field containers for final neutralent storage.

A Vent Drum Scrubber unit will be connected to the vent lines to capture waste tank vapors. This waste vent drum scrubber system will also connect to the system carbon filtration system to ensure capture of harmful vapors coming from the neutralent in the waste tanks while it cools.

Figure 1. ISO Tank Container

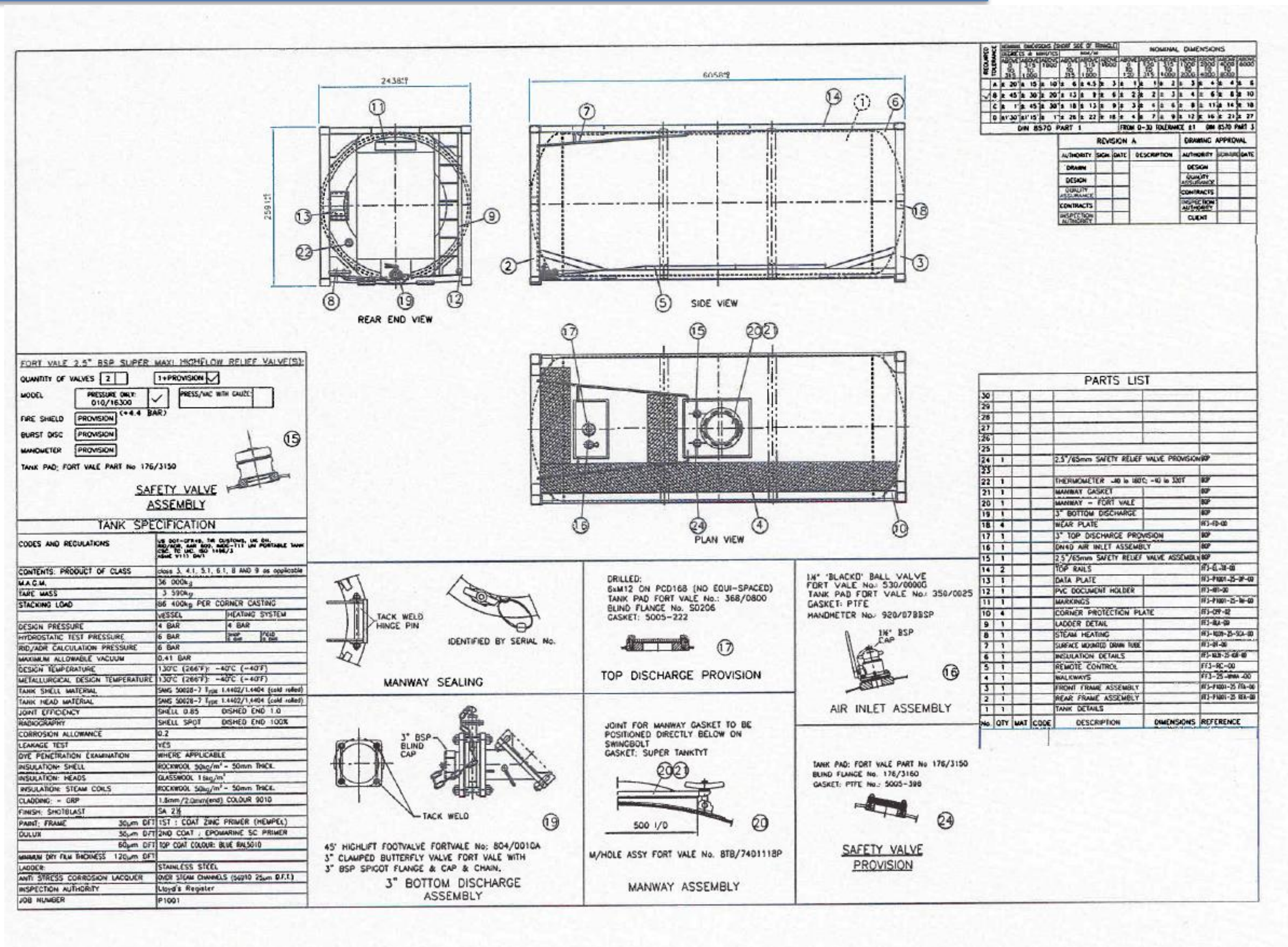

Figure 2. ISO Tank Container Drawing

- **Neutralent Bladders (employed with FDHS)**

Flexible containers in 20,000 gallon capacity will be placed on-site removed sufficiently from the process so as to not to interfere with movement on the process site, to hold the final neutralent solutions. The bladders will be filled from waste ISO tank containers via flexible hose connections and a neutralent pump placed between the initial hose connection and bladder hose connection. Neutralent will maintain reaction chemistry segregation in the field. Once filled, bladders will be fixed on the site for indefinite storage. 80 total bladders are required; table 1 and 2 indicate volume and dimensions.

Total Volume, gal:	1,600,000
Volume of Each Bladder, gal:	20,000

Table 1. Bladder Volume Information

Total Bladders Required	80
Bladder Width, ft:	30
Bladder Length, ft:	19

Table 2. Bladder Dimensions

Several bladder layouts were evaluated, based on pressure drops and hose arrangements, to calculate the optimal configuration of the bladders. Although certain layouts provided lower square footage, they required the greatest lengths of hose. This becomes prohibitive when determining a pump that can overcome the pressure drop from hydrolysate storage to the bladder. Due to the use of flex hoses where pressure drop is even more of a concern, the optimal combination minimizes the length and width to the greatest extent possible. In this case, the arrangement Z noted in Table 3 was chosen. It should be noted that in this arrangement, the bladder would be oriented such that the width is 31 ft and the length would be 22 ft.

Case	Width, 31 ft	Length, 22 ft	Area, sq ft
Z	269	247	66,443

Table 3. Optimal Bladder Arrangement

Each hydrolysate storage vessel will feed a manifold using 50 ft of 3 in flex hose. From the manifold, another 50 ft of 3 in flex hose will feed the suction side of the pump. The distance from the discharge of the pump to the first row of bladders is 50 ft. It should be noted that the discharge side of the pump is a 1.5 in port and will also transfer using a flex hose. An assumption has been made that the bladders will be oriented in such a way that each row is situated equally on each side of the pump's center line.

The furthest distance the pump would need to reach is calculated using the Pythagorean Theorem. The arrangement described by Z yields a width of 269 ft and a length of 247 ft. Because the bladders are set equally on each side of the pump, the length is reduced to half or 123.5 ft. Therefore, the distance from the pump discharge to the furthest bladder is 296 ft. Because geography at the site may affect the arrangement, the greatest performance parameter was accounted for whereby all bladders lie to the right or left of the pump's center line. The furthest distance in this case increases to 365 ft. The length of flex hoses is likely to be 100 ft sections. The best case distance was rounded to 300 ft while the worst-case was rounded to 400 ft.

To determine the pressure drop in 1.5 in flex hose, a flow rate of 30 gpm and 72 gpm was used for the DF and HD process, respectively. The following tables show the loss of pressure by pumping to the bladder farm at its furthest point for the best and worst-case arrangements:

Pressure Drop from Hydrolysate Storage to Furthest Bladder (Optimal Arrangement)

	Length, ft	psi Loss Factor	Pressure Drop, psi
Flex Hose, 1.5", DF Process, 30 gpm	350	0.04	13.30
Flex Hose, 1.5", HD Process, 70 gpm	350	0.17	59.50
Vertical Rise to Bladder	4	0.43	1.73
Back Pressure from Bladder	N/A	N/A	15.00

* Pressure loss in flex hose per 100 ft.	Total Pressure Drop, psi, DF Process:	30.03
** psi drop from vertical rise is ft/2.31	Total Pressure Drop, psi, HD Process:	76.23

Pressure Drop from Hydrolysate Storage to Furthest Bladder (Worst-Case Arrangement)

	Length, ft	psi Loss Factor	Pressure Drop, psi
Flex Hose, 1.5", DF Process, 30 gpm	400	0.04	15.20
Flex Hose, 1.5", HD Process, 70 gpm	400	0.17	68.00
Vertical Rise to Bladder	4	0.43	1.73
Back Pressure from Bladder	N/A	N/A	15.00

* Pressure loss in flex hose per 100 ft.	Total Pressure Drop, psi, DF Process:	31.93
** psi drop from vertical rise is ft/2.31	Total Pressure Drop, psi, HD Process:	84.73

The ANSI Mag K3158 model that will be used in the system as recirculation pumps are more than capable of supplying the flow and pressure given these distances. The suction is 3 in and the discharge is 1.5 in. The top of each bladder is fitted with a 1.5 in port. Whether recirculating the pump to the reactor or discharging to hydrolysate storage, calculations for pressure has been between 5-10 psi at the discharge point. Given the maximum pressure loss from the pump to the furthest bladder is 84.73 psi, the ANSI Mag pump would need to deliver 94.73 psi. These pumps are designed such that, while running at only 58% efficiency, the pump can deliver 94.73 psi or 219 ft of head. Figure 3 depicts the optimized final system design.

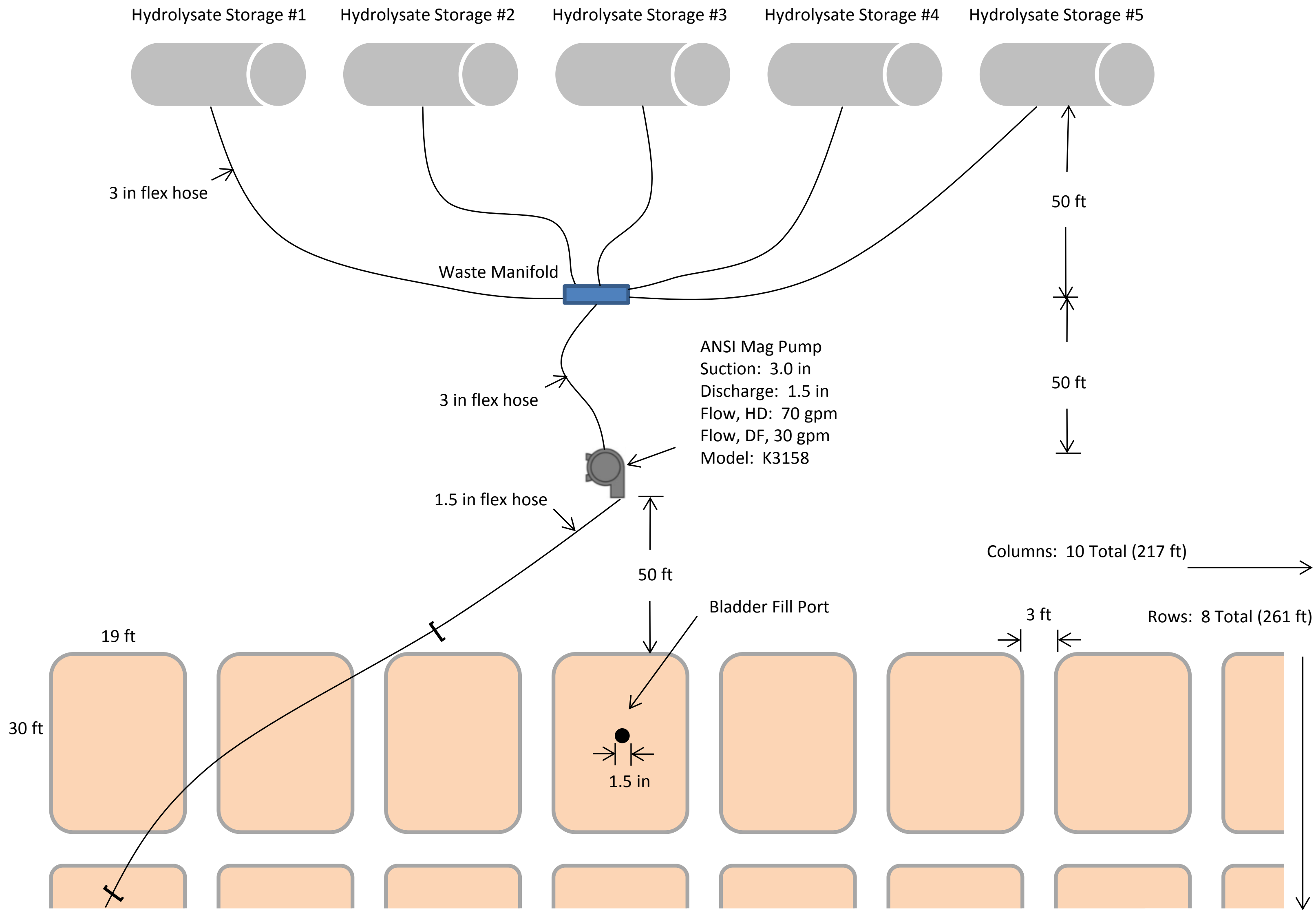

Figure 3. Bladder Farm Layout

For more information, contact JPM-E at 410-436-7992

- **Caustic Neutralant Liquid Waste Evaporation (Disposal Option)**

Liquid waste evaporation allows for significant waste reduction (~80% by weight) by exposing liquid waste by-products to sunlight to evaporate liquid components and leave solid salts, which can then be shoveled into containers. Containment into which the liquid can be poured and exposed to the sun is required but can be constructed with minimal equipment (grading equipment and liner). This disposal capability was considered for effluent final disposition.

Figure 4. Evaporation Pond

- **Solidification (Disposal Option)**

Solidification is another alternative to dispose of waste effluent. Materials that are suitable, readily available, and proven include diatomaceous earth, clay, fly ash, natural gums, and cement. However, cement, specifically Portland Cement, appears to be proven, cost-effective, and the most readily available. It has superior characteristics in the handling of acids and inorganic waste and the cement raises the pH of the solution, providing further stability. With regards to organic compounds, cement solidification is more case specific and less dependable, therefore bench scale testing of cement's capability to solidify EMPTA and amines is necessary. However, asphalt has been proven to be a ready and capable solution to address organic wastes and could be used in concert with cement to provide a comprehensive solution to address all waste profiles.

Figure 5. Solidification example

- **Deep Well Injection**

Figure 6. Deep Well Injection

Deep well injection is a proven method to dispose of waste effluent by injection into the ground between impermeable layers of rocks, usually into porous rock formations such as sandstone or limestone. It avoids polluting fresh water supplies or adversely affecting quality of receiving waters through bypassing underground sources of drinking water by thousands of feet. Injection wells are usually constructed of solid walled pipe and are a cost effective and environmentally friendly method of waste water treatment, providing multiple layers of protective casing and cement. Suitability of the geological strata would need to be determined by drilling and testing.

Deep well injection was analyzed and utilized for the disposal of incineration brine effluent at the chemical stockpile elimination sites. However, the Organisation for the Prohibition of Chemical Weapons has never been asked to accept deep well injection as rendering the components of the hydrolysates as unrecoverable. The impact of any verification requirements imposed by OPCW on a deep well injection facility is unknown.

- **Offsite Disposal**

JPM E has had extensive experience with utilizing offsite commercial disposal of hazardous waste. Over 1.5 million gallons of caustic wastewater, effluent from the VX/NaOH neutralization process, was shipped in 4,000 gallon capacity intermodal containers, for disposal at a hazardous waste incinerator. Bulk quantities of VX were chemically neutralized at the NECDF using a batch process, and then were analyzed to verify destruction of agent to below 20 ppb. Cleared batches were pumped into intermodal containers for temporary storage at the facility prior to transport for disposal.

Over 413 trips by truck were safely completed between Newport, Indiana and Port Arthur, Texas to ship the entire NECDF quantity of process effluent. The waste was classified as a DOT Class 8 (corrosive) shipping hazard. Prior to accepting the waste, the disposal facility permit was updated to allow processing of the constituents of the NECDF effluent. In addition, notification and communications plans were in place with officials and emergency response organizations along the travel route.

Procedures for offloading the liquid at the site were developed and timing was coordinated such that the effluent was pumped into the disposal process directly upon truck arrival.

The implementation of off-site shipment for the disposal of the chemical agent neutralization wastewater provided significant schedule and cost savings, also contributing to earlier elimination of the stockpile risk.

Figure 7. Offsite Disposal